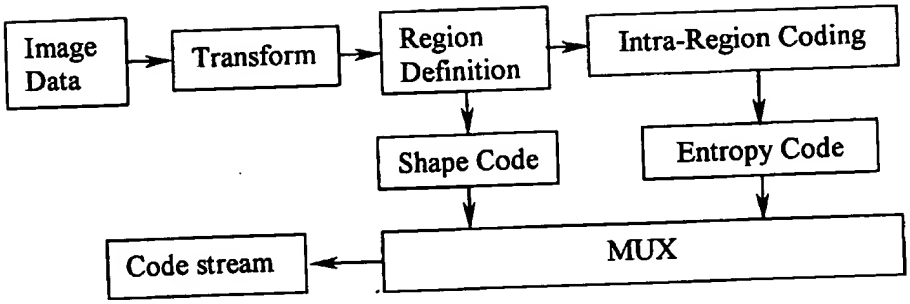


Image Data
Transform
Region Definition
Intra-Region Coding
Shape Code
Entropy Code
MUX
Code stream

FIGURE 1

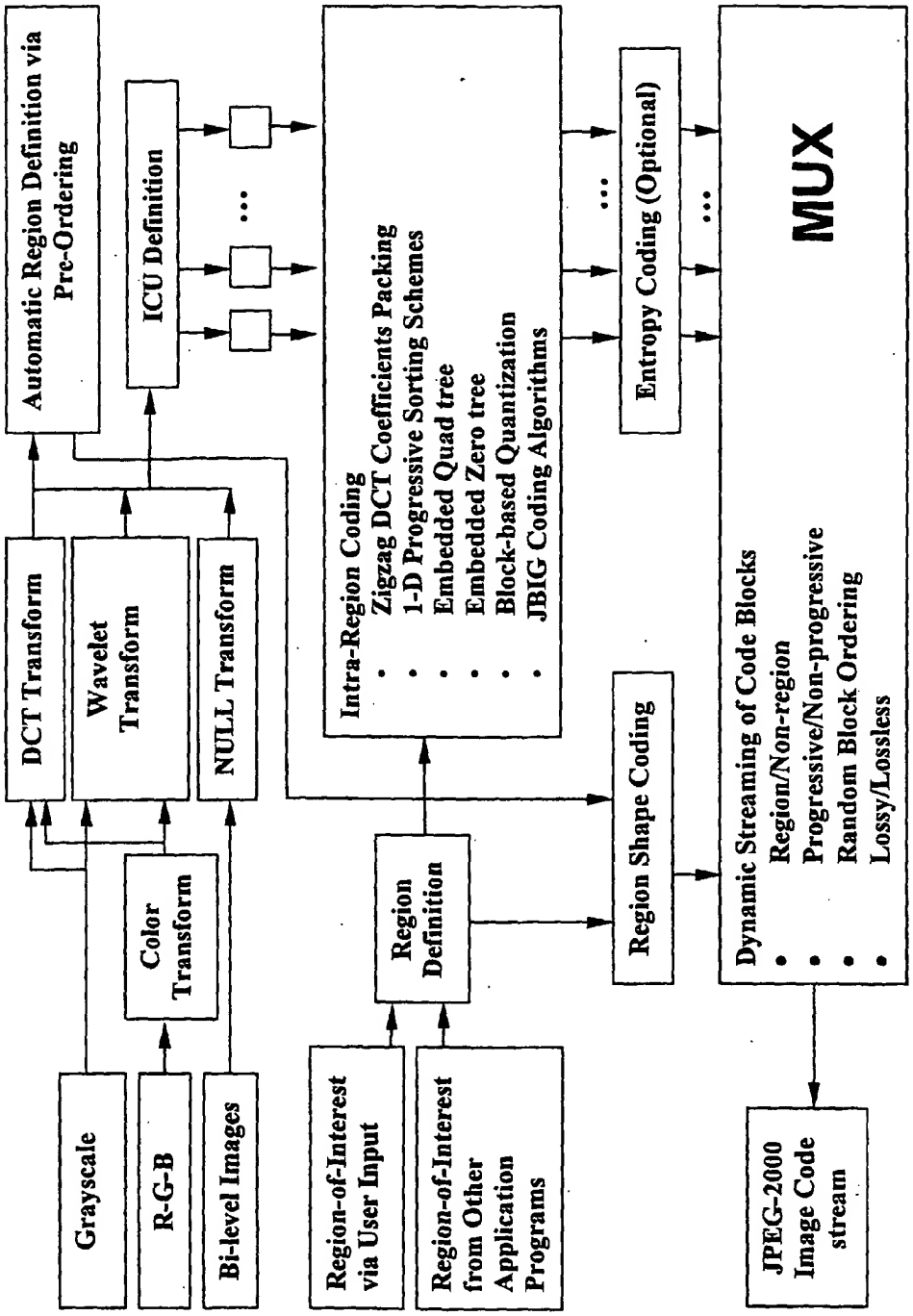

Automatic Region Definition via Pre-Ordering
ICU Definition
DCT Transform
Wavelet Transform
NULL Transform
Color Transform
Region Definition
Intra-Region Coding
• Zigzag DCT Coefficients Packing
• 1-D Progressive Sorting Schemes
• Embedded Quad tree
• Embedded Zero tree
• Block-based Quantization
• JBIG Coding Algorithms
Entropy Coding (Optional)
Region Shape Coding
Dynamic Streaming of Code Blocks
• Region/Non-region
• Progressive/Non-progressive
• Random Block Ordering
• Lossy/Lossless
MUX
Grayscale
R-G-B
Bi-level Images
Region-of-Interest via User Input
Region-of-Interest from Other Application Programs
JPEG-2000 Image Code stream

FIGURE 2

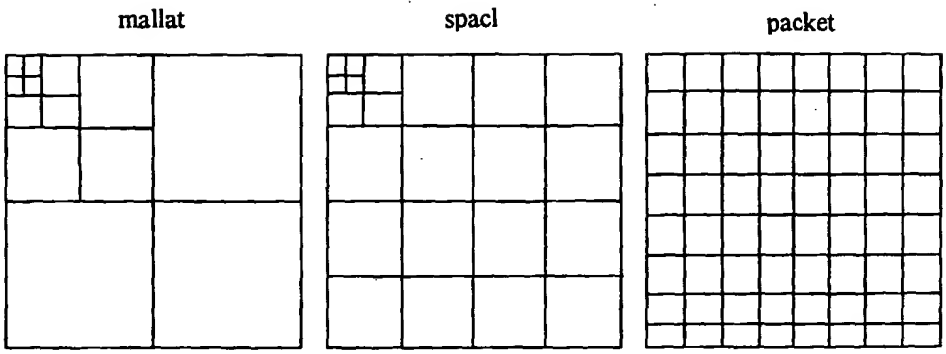


FIGURE 3

Wavelet Family	**Wavelet Type (Filter Length)**							
Haar	Haar (2)							
Daubechies	Db4 (4)	Db6 (6)	Db8 (8)	Db10 (10)	Db12 (12)	Db14 (14)	Db16 (16)	
Coiflet	Coif1 (6)	Coif2 (12)	Coif3 (18)	Coif4 (24)				
Symmlet	Sym2 (4)	Sym3 (6)	Sym4 (8)	Sym5 (10)	Sym6 (12)	Sym7 (14)	Sym8 (16)	
Biorthogonal	Bior1.1 (2)	Bior1.3 (6)	Bior1.5 (10)	Bior2.2 (6)	Bior3.1 (4)	Bior3.3 (8)	Bior4.4 (10)	Bior5.5 (12)
Biorthogonal (Villasenor)	Bior9 (10)9/7	Bior10 (14)	Bior11 (10)	Bior12 (6)	Bior13 (6)	Bior14 (10)	Bior15 10/18	

FIGURE 4

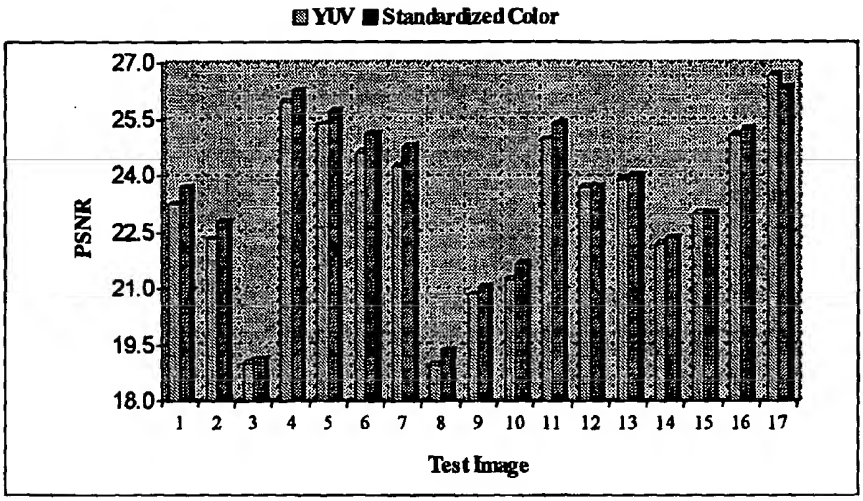


FIGURE 5

Shape	Coding Parameters	Availability in RICS
Rectangle/Square	(x_{min}, y_{min}) and *(width, height) etc.*	present
Circle/Ellipse	(x_0, y_0) and r etc.	present
Polygon	$n, (x_1, y_1), (x_2, y_2) \ldots (x_n, y_n)$	Under development
Cubic parametric curves	$n, (x_1, y_1), (x_2, y_2) \ldots (x_n, y_n)$	Under development

FIGURE 6

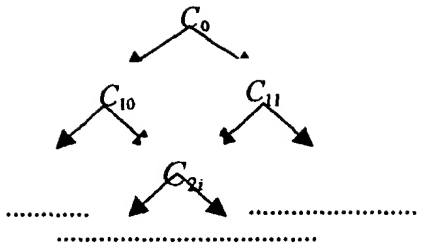
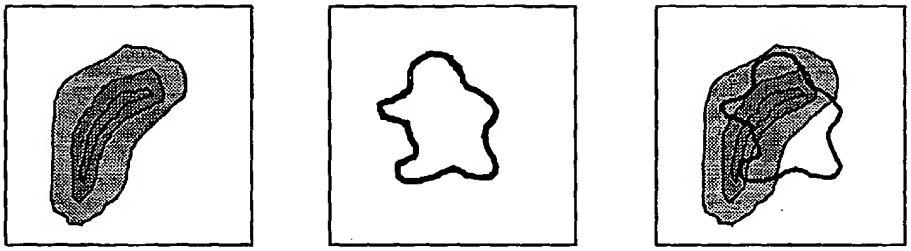


FIGURE 7



Region Mask | Dynamic Object | Extracted Dynamic Regions

FIGURE 8

HL_1 LH_1 HH_1

FIGURE 9

FIGURE 10

FIGURE 11

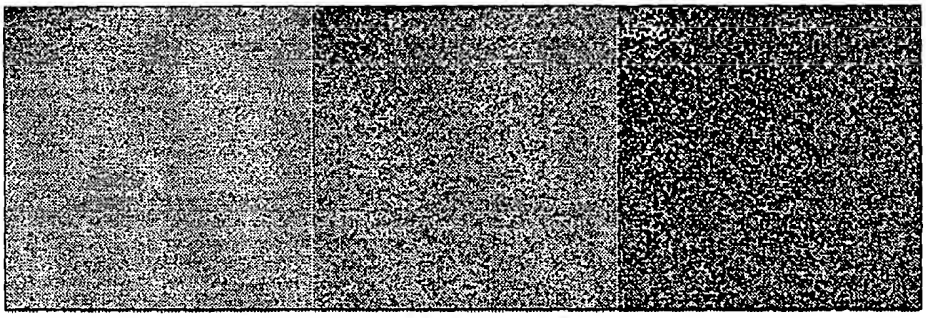


FIGURE 12

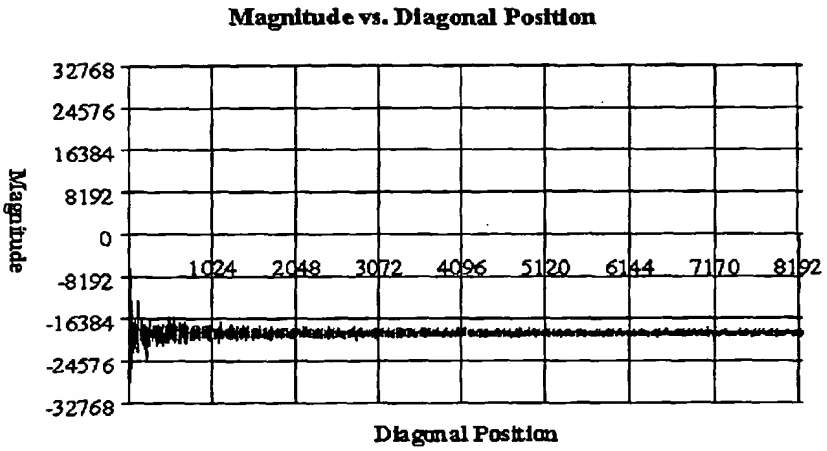


FIGURE 13

Common Mask Dimension	Spectral Filter Size	Included Spectral Coefficients
32 x 32	32	528
64 x 64	38	741
128 x 128	44	990
256 x 256	52	1378
512 x 512	61	1891
1024 x 1024	71	2556

FIGURE 14

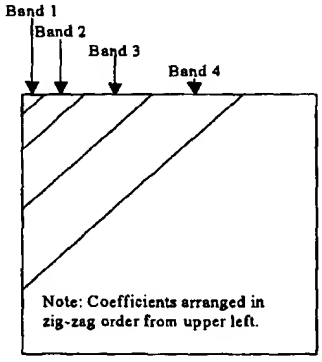


FIGURE 15

Band	Diagonal Rows	Included Spectral Coefficients
1	3	6
2	6	39
3	12	186
4	24	804

FIGURE 16

Mask Spectrum Size	Band 1 Rows	Band 2 Rows	Band 3 Rows	Band 4 Rows
32 x 32	1	2	4	8
64 x 64	2	4	8	16
128 x 128	3	6	12	24
256 x 256	4	8	16	32
512 x 512	5	10	20	40

FIGURE 17

Image Size (pixels)	Image Size (bytes)	Mask Overhead (bytes)	Mask Overhead (%)
64 x 64	4096	546	13.3
128 x 128	16384	764	4.6
256 x 256	65536	1021	1.6
512 x 512	262144	1420	0.5
1024 x 1024	1048576	1948	0.2

FIGURE 18

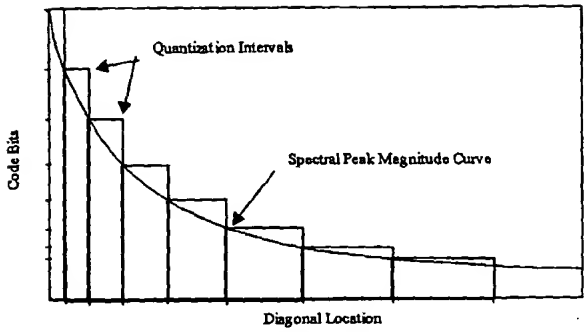


FIGURE 20

FIGURE 21

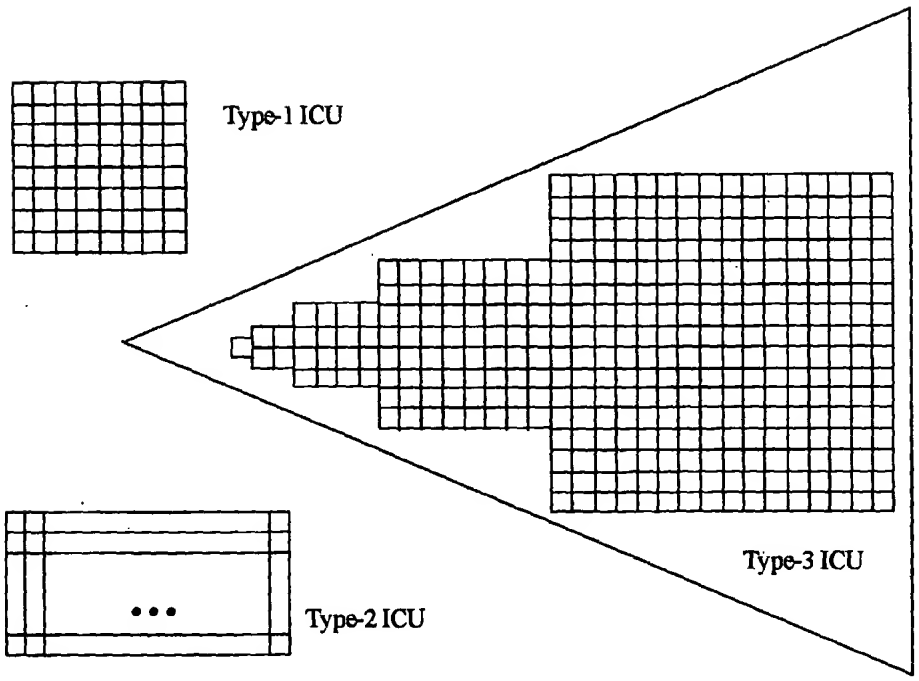


FIGURE 22

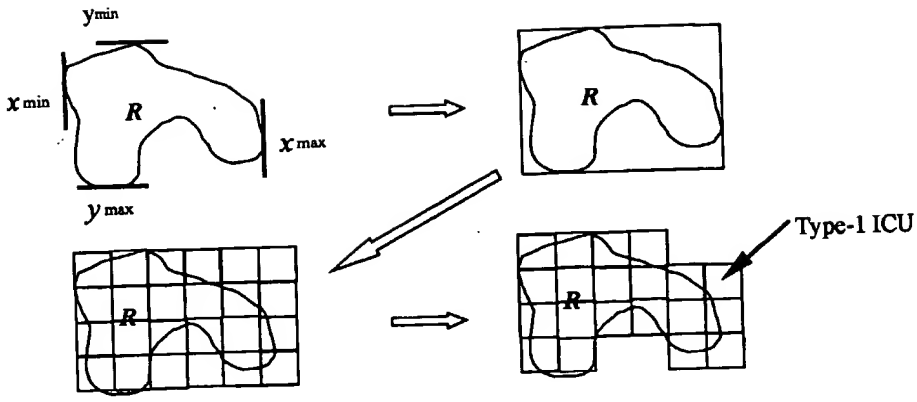


FIGURE 23

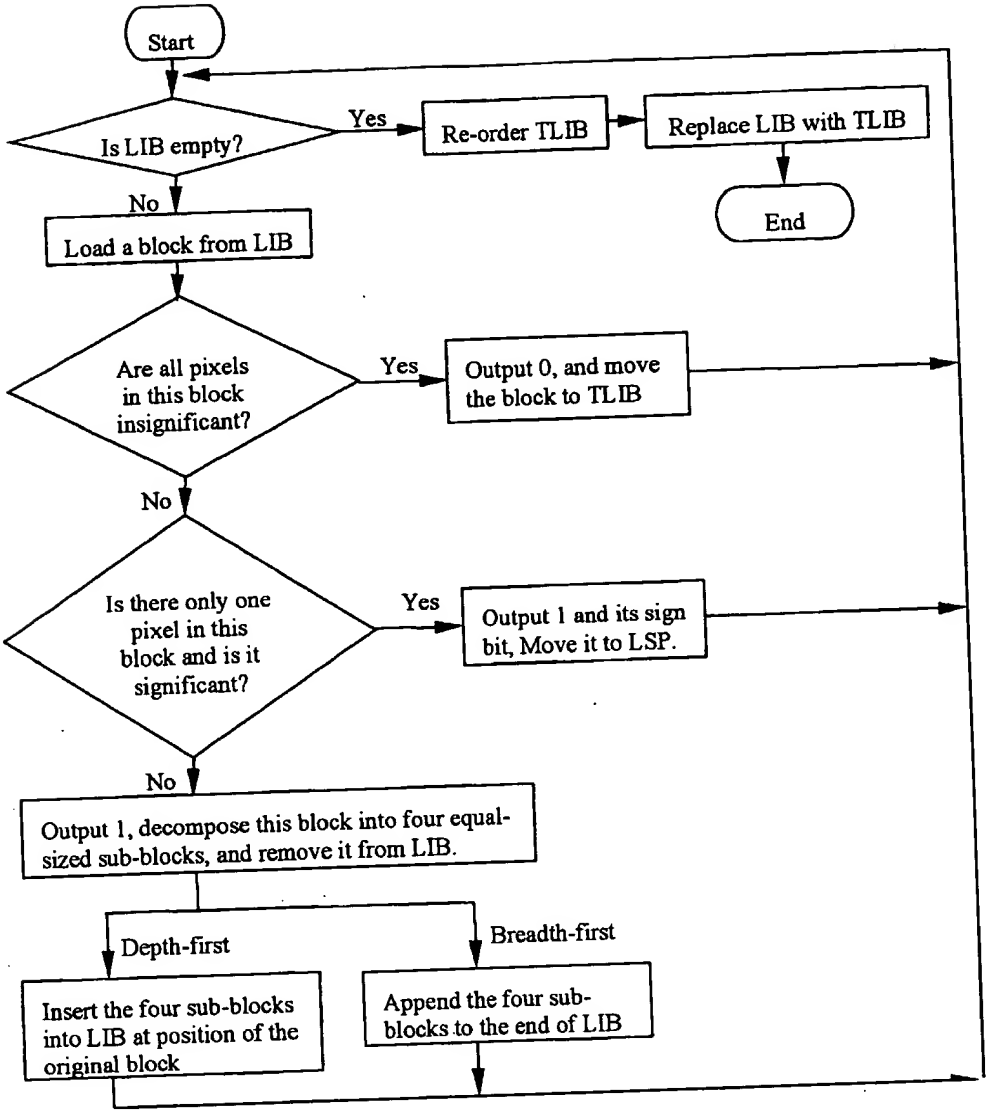

Start
Is LIB empty?
Yes
Re-order TLIB
Replace LIB with TLIB
End
No
Load a block from LIB
Are all pixels in this block insignificant?
Yes
Output 0, and move the block to TLIB
No
Is there only one pixel in this block and is it significant?
Yes
Output 1 and its sign bit, Move it to LSP.
No
Output 1, decompose this block into four equal-sized sub-blocks, and remove it from LIB.
Depth-first
Breadth-first
Insert the four sub-blocks into LIB at position of the original block
Append the four sub-blocks to the end of LIB

FIGURE 24

For LL Subband		For Blocks f Size nxn (n>2) of Other Subbands		F r Other Types of Blocks	
Sequence	VLC Code	Sequence	VLC Code	Sequence	VLC Code
1111	000	0001	000	0001	000
1010	001	0010	001	0010	001
0101	010	0100	010	0100	010
0100	011	1111	011	1000	011
1110	1000	0011	1000	1100	1000
1101	1001	1000	1001	1010	1001
0111	1010	1100	1010	0101	1010
0010	1011	1101	1011	0011	1011
1100	11000	0101	11000	0110	11000
1011	11001	0110	11001	0111	11001
1001	11010	0111	11010	1001	11010
1000	11011	1001	11011	1011	11011
0110	11100	1010	11100	1101	11100
0011	11101	1011	11101	1110	11101
0001	11110	1110	11110	1111	11110

FIGURE 25

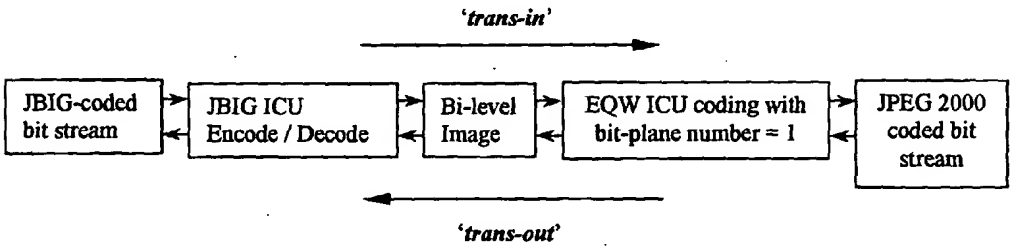


FIGURE 26

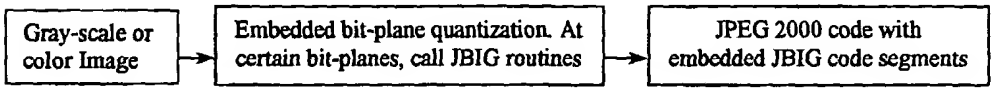


FIGURE 27

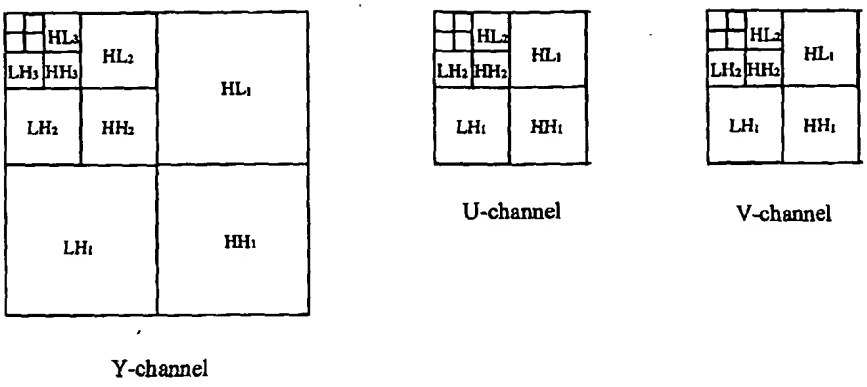


FIGURE 28

Y-channel: LL_4-HL_4-LH_4-HH_4-HL_3-LH_3-HH_3-HL_2-LH_2-HH_2- HL_1-LH_1-HH_1
U-channel: LL_3- HL_3-LH_3-HH_3-HL_2-LH_2-HH_2- HL_1-LH_1-HH_1
V-channel: LL_3- HL_3-LH_3-HH_3-HL_2-LH_2-HH_2-HL_1-LH_1-HH_1

FIGURE 29

Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}-
Y_{HL3}-Y_{LH3}-Y_{HH3}-U_{HL3}-U_{LH3}-U_{HH3}-V_{HL3}-V_{LH3}-V_{HH3}-
Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}-
Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1}

FIGURE 30

Y_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{LL3}-V_{LL3}-
Y_{HL3}-U_{HL3}-V_{HL3}-Y_{LH3}-U_{LH3}-V_{LH3}-Y_{HH3}-U_{HH3}-V_{HH3}-
Y_{HL2}-U_{HL2}-V_{HL2}-Y_{LH2}-U_{LH2}-V_{LH2}-Y_{HH2}-U_{HH2}-V_{HH2}-
Y_{HL1}-U_{HL1}-V_{HL1}-Y_{LH1}-U_{LH1}-V_{LH1}-Y_{HH1}-U_{HH1}-V_{HH1}

FIGURE 31

Y_{LL4}-U_{LL4}-V_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL4}-V_{LH4}-V_{HH4}-
Y_{HL3}-Y_{LH3}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL3}-V_{LH3}-V_{HH3}-
Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}-
Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1}

FIGURE 32

Y_{LL4}-U_{LL4}-V_{LL4}-Y_{HL4}- U_{HL4}-V_{HL4}-Y_{LH4}-U_{LH4}-V_{LH4}-Y_{HH4}-U_{HH4}-V_{HH4}
Y_{HL3}-U_{HL3}-V_{HL3}-Y_{LH3}-U_{LH3}-V_{LH3}-Y_{HH3}-U_{HH3}-V_{HH3}
Y_{HL2}-U_{HL2}-V_{HL2}-Y_{LH2}-U_{LH2}-V_{LH2}-Y_{HH2}-U_{HH2}-V_{HH2}
Y_{HL1}-U_{HL1}-V_{HL1}-Y_{LH1}-U_{LH1}-V_{LH1}-Y_{HH1}-U_{HH1}-V_{HH1}

FIGURE 33

Data Type: MUXLIST

Parameters:

liTotBytesPacked	- long integer total bytes packed into the data buffer for this list.
cScheme	- character processing scheme used for data contained in this list.
cHighBit	- character highest bit-level where data processing begins for this list.
*pucMuxBuff	- pointer to unsigned character buffer where data for each bit-level is packed for this list.

Fields for MUX: information for packing after list processing is complete.

pliBitPackInfo[16]	- pointer to long integer number of bits packed into the data buffer at each bit-level for this list.
liCurBytesCount	- long integer current byte count used for bit budget distribution when packing this list.
cCurBitLevel	- character current bit-level used for packing this list.
cRemainingBits	- character remaining bits to be packed at a given bit-level when data to be packed is not evenly divisible by 8 for this list.

FIGURE 34

```
CALCULATE Channel BitBudget // determine optimal bit-budget for each color channel.
INITIALIZE Channel CurrentBitPlane // highest bit plane that exists in each color channel.
INITIALIZE liCurBytesCount and cRemainingBits FOR each MUX list

FOR Each Color Channel // process each channel separately.
    WHILE Channel BitBudget > 0 AND Channel CurrentBitPlane >=0
        FOR Each Wavelet Transform level // beginning at lowest resolution level.
            FOR Each Orientation Set of Data // according to lossy case natural processing order.
                IF cCurBitLevel NOT_EQUAL to Channel CurrentBitPlane
                    CONTINUE
                ELSE
                    SET BitLevelBytes to pliBitPackInfo[Channel CurrentBitPlane] >> 3
                    SET RemBits to pliBitPackInfo[Channel CurrentBitPlane] & 7
                    IF Sum(cRemainingBits, RemBits) >= 8
                        INCREMENT BitLevelBytes by 1
                        DECREMENT cRemainingBits by 8 – RemBits
                    ELSE
                        INCREMENT cRemainingBits by RemBits
                    ENDIF
                    IF Channel BitBudget >= BitLevelBytes
                        INCREMENT liCurBytesCount by BitLevelBytes
                        DECREMENT Channel BitBudget by BitLevelBytes
                        DECREMENT cCurBitLevel by 1
                    ELSE
                        INCREMENT liCurBytesCount by Channel BitBudget
                        SET Channel BitBudget to 0
                    ENDIF
                ENDIF
                IF Channel BitBudget EQUALS 0
                    BREAK
                ENDIF
            END FOR
        END FOR
        DECREMENT Channel CurBitPlane by 1
    END WHILE
END FOR
```

FIGURE 35

Orientation	Max. Data Size (Bytes)	Req. Bits	Req. Bits for High Bit
LL_8	$2x8^2$	7	4
HL_8	$2x8^2$	7	4
LH_8	$2x8^2$	7	4
HH_8	$2x8^2$	7	4
HL_7	$2x16^2$	9	4
LH_7	$2x16^2$	9	4
HH_7	$2x16^2$	9	4
HL_6	$2x32^2$	11	4
LH_6	$2x32^2$	11	4
HH_6	$2x32^2$	11	4
HL_5	$2x64^2$	13	4
LH_5	$2x64^2$	13	4
HH_5	$2x64^2$	13	4
HL_4	$2x128^2$	15	4
LH_4	$2x128^2$	15	4
HH_4	$2x128^2$	15	4
HL_3	$2x256^2$	17	4
LH_3	$2x256^2$	17	4
HH_3	$2x256^2$	17	4
HL_2	$2x512^2$	19	4
LH_2	$2x512^2$	19	4
HH_2	$2x512^2$	19	4
HL_1	$2x1024^2$	21	4
LH_1	$2x1024^2$	21	4
HH_1	$2x1024^2$	21	4
	Total Header Bits	**343**	**100**

FIGURE 36

Image Dimension (Rows & Columns)	Overhead Bits (Lossy)	Overhead Bits (Lossless)	Overhead Bits (GrayScale)
16	44	132	44
32	171	249	83
64	294	384	128
128	435	537	179
256	594	708	236
512	771	897	299
1024	966	1104	368
2048	1179	1329	443
4096	1410	1572	525
8192	1659	1833	611
16384	1926	2112	704
32768	2211	2409	803
65536	2514	2724	908

FIGURE 37

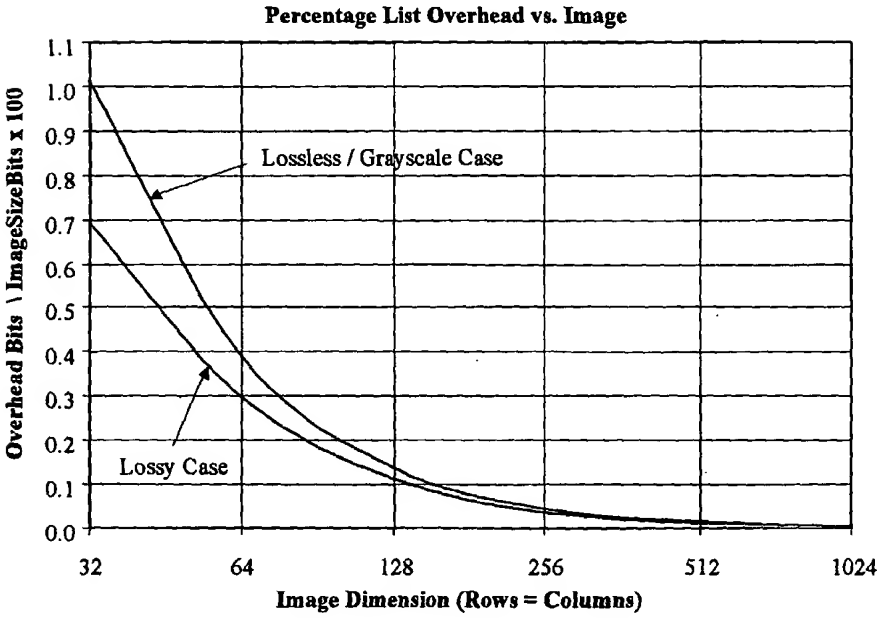


FIGURE 38

Y-channel: $R_1(LL_4\text{-}HL_4\text{-}LH_4\text{-}HH_4\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$,
$R_2(LL_4\text{-}HL_4\text{-}LH_4\text{-}HH_4\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$,
$R_3(LL_4\text{-}HL_4\text{-}LH_4\text{-}HH_4\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$,
$R_4(LL_4\text{-}HL_4\text{-}LH_4\text{-}HH_4\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$.

U-channel: $R_1(LL_3\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$,
$R_2(LL_3\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$,
$R_3(LL_3\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$,
$R_4(LL_3\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$.

V-channel: $R_1(LL_3\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$,
$R_2(LL_3\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$,
$R_3(LL_3\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$,
$R_4(LL_3\text{-}HL_3\text{-}LH_3\text{-}HH_3\text{-}HL_2\text{-}LH_2\text{-}HH_2\text{-}HL_1\text{-}LH_1\text{-}HH_1)$.

FIGURE 39

$R_1(Y_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{LL3}\text{-}V_{LL3}\text{-}$
$Y_{HL3}\text{-}Y_{LH3}\text{-}Y_{HH3}\text{-}U_{HL3}\text{-}U_{LH3}\text{-}U_{HH3}\text{-}V_{HL3}\text{-}V_{LH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}Y_{LH2}\text{-}Y_{HH2}\text{-}U_{HL2}\text{-}U_{LH2}\text{-}U_{HH2}\text{-}V_{HL2}\text{-}V_{LH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}Y_{LH1}\text{-}Y_{HH1}\text{-}U_{HL1}\text{-}U_{LH1}\text{-}U_{HH1}\text{-}V_{HL1}\text{-}V_{LH1}\text{-}V_{HH1})$,
$R_2(Y_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{LL3}\text{-}V_{LL3}\text{-}$
$Y_{HL3}\text{-}Y_{LH3}\text{-}Y_{HH3}\text{-}U_{HL3}\text{-}U_{LH3}\text{-}U_{HH3}\text{-}V_{HL3}\text{-}V_{LH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}Y_{LH2}\text{-}Y_{HH2}\text{-}U_{HL2}\text{-}U_{LH2}\text{-}U_{HH2}\text{-}V_{HL2}\text{-}V_{LH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}Y_{LH1}\text{-}Y_{HH1}\text{-}U_{HL1}\text{-}U_{LH1}\text{-}U_{HH1}\text{-}V_{HL1}\text{-}V_{LH1}\text{-}V_{HH1})$,
$R_3(Y_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{LL3}\text{-}V_{LL3}\text{-}$
$Y_{HL3}\text{-}Y_{LH3}\text{-}Y_{HH3}\text{-}U_{HL3}\text{-}U_{LH3}\text{-}U_{HH3}\text{-}V_{HL3}\text{-}V_{LH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}Y_{LH2}\text{-}Y_{HH2}\text{-}U_{HL2}\text{-}U_{LH2}\text{-}U_{HH2}\text{-}V_{HL2}\text{-}V_{LH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}Y_{LH1}\text{-}Y_{HH1}\text{-}U_{HL1}\text{-}U_{LH1}\text{-}U_{HH1}\text{-}V_{HL1}\text{-}V_{LH1}\text{-}V_{HH1})$,
$R_4(Y_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{LL3}\text{-}V_{LL3}\text{-}$
$Y_{HL3}\text{-}Y_{LH3}\text{-}Y_{HH3}\text{-}U_{HL3}\text{-}U_{LH3}\text{-}U_{HH3}\text{-}V_{HL3}\text{-}V_{LH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}Y_{LH2}\text{-}Y_{HH2}\text{-}U_{HL2}\text{-}U_{LH2}\text{-}U_{HH2}\text{-}V_{HL2}\text{-}V_{LH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}Y_{LH1}\text{-}Y_{HH1}\text{-}U_{HL1}\text{-}U_{LH1}\text{-}U_{HH1}\text{-}V_{HL1}\text{-}V_{LH1}\text{-}V_{HH1})$.

FIGURE 40

$R_1(Y_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{LL3}\text{-}V_{LL3}\text{-}$
$Y_{HL3}\text{-}U_{HL3}\text{-}V_{HL3}\text{-}Y_{LH3}\text{-}U_{LH3}\text{-}V_{LH3}\text{-}Y_{HH3}\text{-}U_{HH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}U_{HL2}\text{-}V_{HL2}\text{-}Y_{LH2}\text{-}U_{LH2}\text{-}V_{LH2}\text{-}Y_{HH2}\text{-}U_{HH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}U_{HL1}\text{-}V_{HL1}\text{-}Y_{LH1}\text{-}U_{LH1}\text{-}V_{LH1}\text{-}Y_{HH1}\text{-}U_{HH1}\text{-}V_{HH1}),$
$R_2(Y_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{LL3}\text{-}V_{LL3}\text{-}$
$Y_{HL3}\text{-}U_{HL3}\text{-}V_{HL3}\text{-}Y_{LH3}\text{-}U_{LH3}\text{-}V_{LH3}\text{-}Y_{HH3}\text{-}U_{HH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}U_{HL2}\text{-}V_{HL2}\text{-}Y_{LH2}\text{-}U_{LH2}\text{-}V_{LH2}\text{-}Y_{HH2}\text{-}U_{HH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}U_{HL1}\text{-}V_{HL1}\text{-}Y_{LH1}\text{-}U_{LH1}\text{-}V_{LH1}\text{-}Y_{HH1}\text{-}U_{HH1}\text{-}V_{HH1}),$
$R_3(Y_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{LL3}\text{-}V_{LL3}\text{-}$
$Y_{HL3}\text{-}U_{HL3}\text{-}V_{HL3}\text{-}Y_{LH3}\text{-}U_{LH3}\text{-}V_{LH3}\text{-}Y_{HH3}\text{-}U_{HH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}U_{HL2}\text{-}V_{HL2}\text{-}Y_{LH2}\text{-}U_{LH2}\text{-}V_{LH2}\text{-}Y_{HH2}\text{-}U_{HH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}U_{HL1}\text{-}V_{HL1}\text{-}Y_{LH1}\text{-}U_{LH1}\text{-}V_{LH1}\text{-}Y_{HH1}\text{-}U_{HH1}\text{-}V_{HH1}),$
$R_4(Y_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{LL3}\text{-}V_{LL3}\text{-}$
$Y_{HL3}\text{-}U_{HL3}\text{-}V_{HL3}\text{-}Y_{LH3}\text{-}U_{LH3}\text{-}V_{LH3}\text{-}Y_{HH3}\text{-}U_{HH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}U_{HL2}\text{-}V_{HL2}\text{-}Y_{LH2}\text{-}U_{LH2}\text{-}V_{LH2}\text{-}Y_{HH2}\text{-}U_{HH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}U_{HL1}\text{-}V_{HL1}\text{-}Y_{LH1}\text{-}U_{LH1}\text{-}V_{LH1}\text{-}Y_{HH1}\text{-}U_{HH1}\text{-}V_{HH1}).$

FIGURE 41

$R1(Y_{LL4}\text{-}U_{LL4}\text{-}V_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{HL4}\text{-}U_{LH4}\text{-}U_{HH4}\text{-}V_{HL4}\text{-}V_{LH4}\text{-}V_{HH4}\text{-}$
$Y_{HL3}\text{-}Y_{LH3}\text{-}Y_{HH4}\text{-}U_{HL4}\text{-}U_{LH4}\text{-}U_{HH4}\text{-}V_{HL3}\text{-}V_{LH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}Y_{LH2}\text{-}Y_{HH2}\text{-}U_{HL2}\text{-}U_{LH2}\text{-}U_{HH2}\text{-}V_{HL2}\text{-}V_{LH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}Y_{LH1}\text{-}Y_{HH1}\text{-}U_{HL1}\text{-}U_{LH1}\text{-}U_{HH1}\text{-}V_{HL1}\text{-}V_{LH1}\text{-}V_{HH1}),$
$R2(Y_{LL4}\text{-}U_{LL4}\text{-}V_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{HL4}\text{-}U_{LH4}\text{-}U_{HH4}\text{-}V_{HL4}\text{-}V_{LH4}\text{-}V_{HH4}\text{-}$
$Y_{HL3}\text{-}Y_{LH3}\text{-}Y_{HH4}\text{-}U_{HL4}\text{-}U_{LH4}\text{-}U_{HH4}\text{-}V_{HL3}\text{-}V_{LH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}Y_{LH2}\text{-}Y_{HH2}\text{-}U_{HL2}\text{-}U_{LH2}\text{-}U_{HH2}\text{-}V_{HL2}\text{-}V_{LH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}Y_{LH1}\text{-}Y_{HH1}\text{-}U_{HL1}\text{-}U_{LH1}\text{-}U_{HH1}\text{-}V_{HL1}\text{-}V_{LH1}\text{-}V_{HH1}),$
$R3(Y_{LL4}\text{-}U_{LL4}\text{-}V_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{HL4}\text{-}U_{LH4}\text{-}U_{HH4}\text{-}V_{HL4}\text{-}V_{LH4}\text{-}V_{HH4}\text{-}$
$Y_{HL3}\text{-}Y_{LH3}\text{-}Y_{HH4}\text{-}U_{HL4}\text{-}U_{LH4}\text{-}U_{HH4}\text{-}V_{HL3}\text{-}V_{LH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}Y_{LH2}\text{-}Y_{HH2}\text{-}U_{HL2}\text{-}U_{LH2}\text{-}U_{HH2}\text{-}V_{HL2}\text{-}V_{LH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}Y_{LH1}\text{-}Y_{HH1}\text{-}U_{HL1}\text{-}U_{LH1}\text{-}U_{HH1}\text{-}V_{HL1}\text{-}V_{LH1}\text{-}V_{HH1}),$
$R4(Y_{LL4}\text{-}U_{LL4}\text{-}V_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{HL4}\text{-}U_{LH4}\text{-}U_{HH4}\text{-}V_{HL4}\text{-}V_{LH4}\text{-}V_{HH4}\text{-}$
$Y_{HL3}\text{-}Y_{LH3}\text{-}Y_{HH4}\text{-}U_{HL4}\text{-}U_{LH4}\text{-}U_{HH4}\text{-}V_{HL3}\text{-}V_{LH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}Y_{LH2}\text{-}Y_{HH2}\text{-}U_{HL2}\text{-}U_{LH2}\text{-}U_{HH2}\text{-}V_{HL2}\text{-}V_{LH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}Y_{LH1}\text{-}Y_{HH1}\text{-}U_{HL1}\text{-}U_{LH1}\text{-}U_{HH1}\text{-}V_{HL1}\text{-}V_{LH1}\text{-}V_{HH1}).$

FIGURE 42

$Y_{LL4}\text{-}Y_{HL4}\text{-}Y_{LH4}\text{-}Y_{HH4}\text{-}U_{LL3}\text{-}V_{LL3}\text{-}$
$Y_{HL3}\text{-}Y_{LH3}\text{-}Y_{HH3}\text{-}U_{HL3}\text{-}U_{LH3}\text{-}U_{HH3}\text{-}V_{HL3}\text{-}V_{LH3}\text{-}V_{HH3}\text{-}$
$Y_{HL2}\text{-}Y_{LH2}\text{-}Y_{HH2}\text{-}U_{HL2}\text{-}U_{LH2}\text{-}U_{HH2}\text{-}V_{HL2}\text{-}V_{LH2}\text{-}V_{HH2}\text{-}$
$Y_{HL1}\text{-}Y_{LH1}\text{-}Y_{HH1}\text{-}U_{HL1}\text{-}U_{LH1}\text{-}U_{HH1}\text{-}V_{HL1}\text{-}V_{LH1}\text{-}V_{HH1}$ (R1, R2, R3 , R4).

FIGURE 43

Y_{LL4}-U_{LL4}-V_{LL4}-Y_{HL4}-Y_{LH4}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL4}-V_{LH4}-V_{HH4}-
Y_{HL3}-Y_{LH3}-Y_{HH4}-U_{HL4}-U_{LH4}-U_{HH4}-V_{HL3}-V_{LH3}-V_{HH3}-
Y_{HL2}-Y_{LH2}-Y_{HH2}-U_{HL2}-U_{LH2}-U_{HH2}-V_{HL2}-V_{LH2}-V_{HH2}-
Y_{HL1}-Y_{LH1}-Y_{HH1}-U_{HL1}-U_{LH1}-U_{HH1}-V_{HL1}-V_{LH1}-V_{HH1} (R1, R2, R3, R4)

FIGURE 44

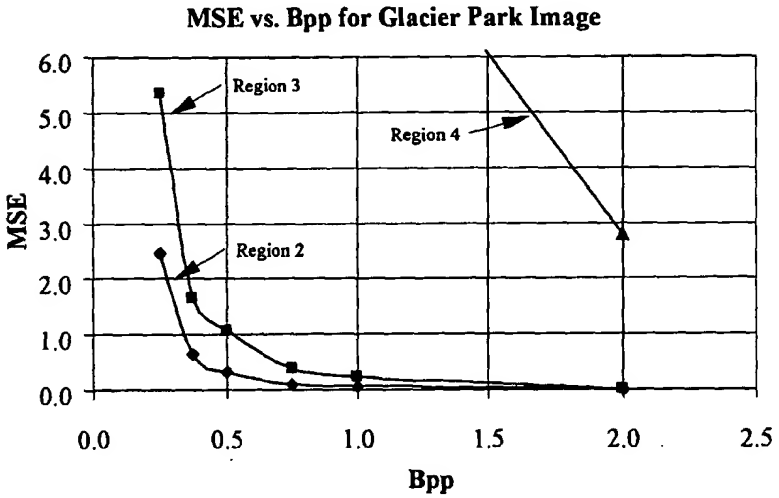


FIGURE 45

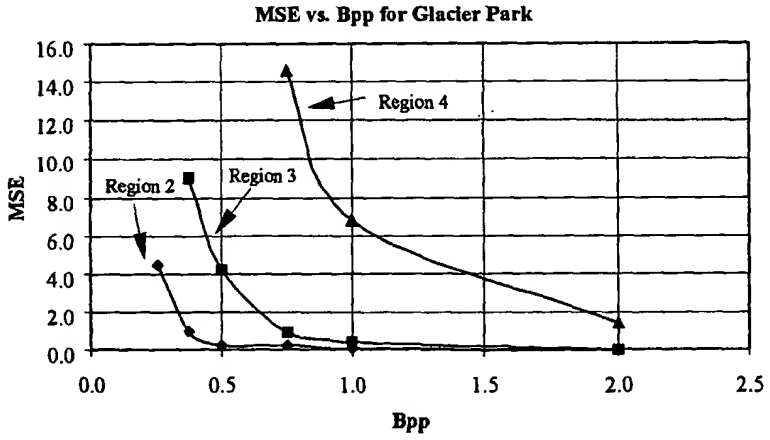


FIGURE 46

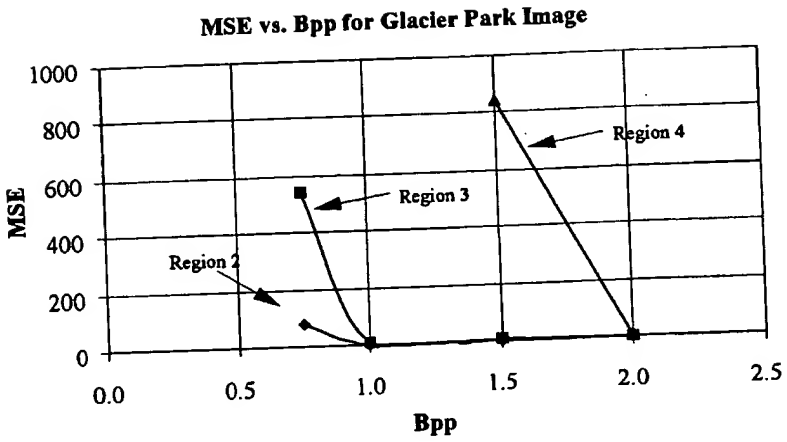


FIGURE 47

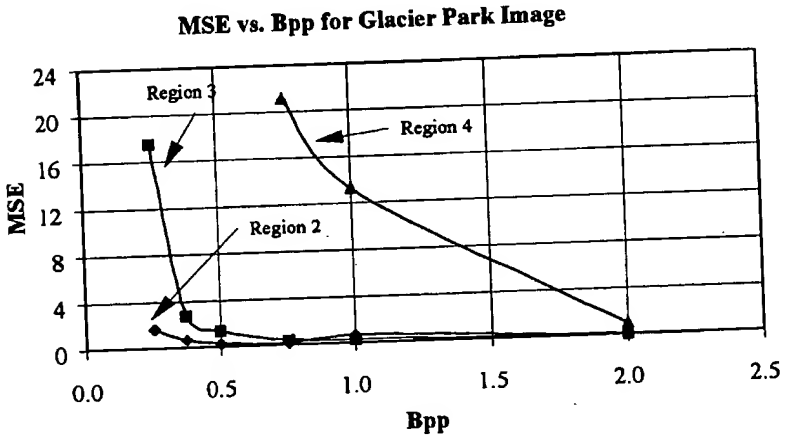


FIGURE 48

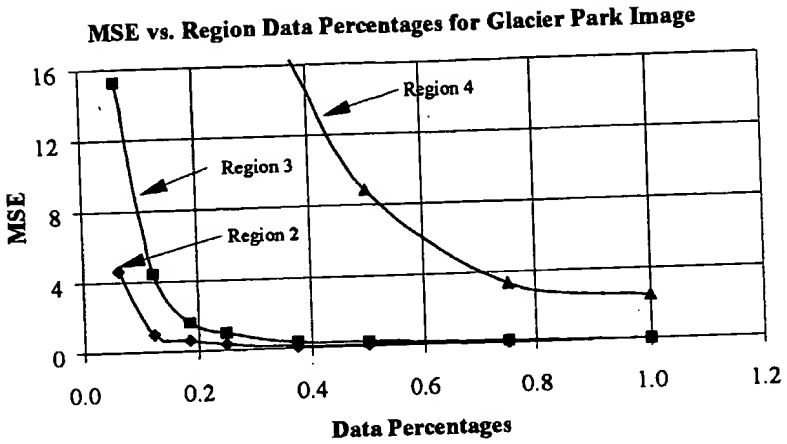


FIGURE 49

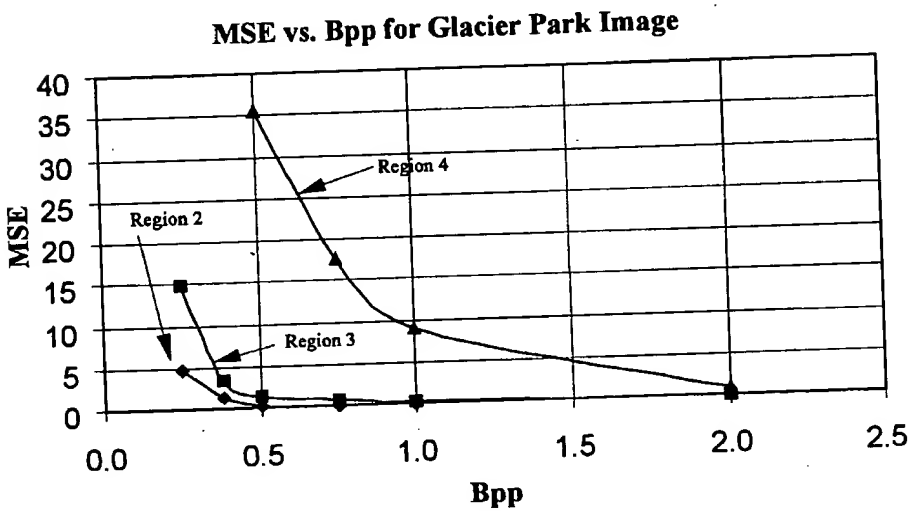


FIGURE 50

Lossless Case		
Packed Item	**bits**	**Selections / Comments**
header size	8	Total Header is normally about 6 bytes
8 bit grayscale / 24 bit color	1	
Image Width	10	(64-1024 columns)
Entropy Coding	2	None, Basic, Adaptive
Image Height	10	(64-1024 rows)
Wavelet Transform Levels	3	Level >= 1
Region Channels	2	1, 2, 3, 4
Mask Type	2	None, User, Auto (DCT)
Pack Raw Mask Flag	1	Read in file for mask
Mask Procedure	3	DCT Common Mask, Raw Common Mask with VM Translation,
Down Sampling Type	2	Heuristic DCT Down Sampling
Region Start Level	4	No Regions to # wavelet levels
Lossy Flag	1	Lossless
Color Transform Type	2	2 Internal, YIQ (full data sets)
Sort Type	1	1D, EQW
Wavelet Kernel	2	Lifting Scheme

FIGURE 51

Lossy Case

Packed Item	bits	Selections
header size	8	Between 6 to 12 bytes
8 bit grayscale / 24 bit color	1	
Image Width	10	(64-1024)
Image Height	10	(64-1024)
Wavelet Transform Levels	3	L >= 2
Region Channels	2	1, 2, 3, 4
Mask Type	2	None, User, Auto (DCT)
Pack Raw Mask Flag	1	Read in file for mask
Mask Procedure	3	DCT Common Mask, Raw Common Mask with VM Resolution Translation, User primitives Common or Full Size, User arbitrarily defined in Common and Full sizes
Down Sampling Type	2	Heuristic DCT Down Sampling
Region Start Level	4	No Regions to #wavelet levels
Lossy Flag	1	lossy
Color Transform Type	2	2 Internal, KL, YIQ, YUV (down sampled data sets)
Post Filter	1	Under Implementation
Sort Type	1	1D, EQW
Wavelet Kernel	3	Daubaches, Symlet, Coiflet, Biorthogonal, Lifting Schemes
Filter Type	4	Various common filter types/sizes
KL Color Transform	48	(if enabled)

FIGURE 52

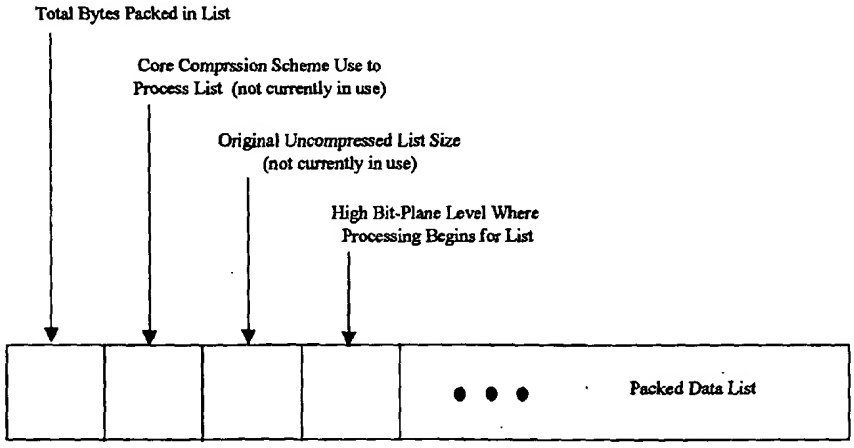


FIGURE 53

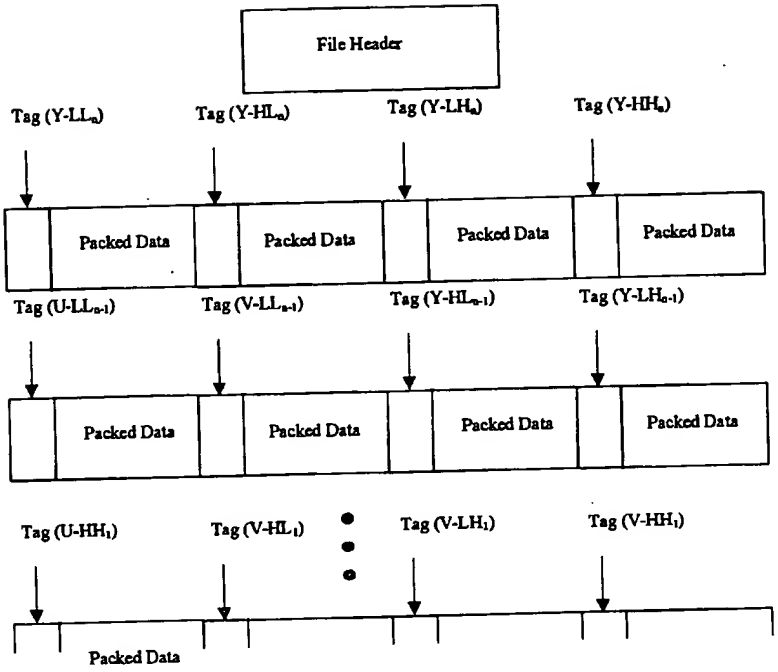

File Header
Tag (Y-LL$_n$)
Tag (Y-HL$_n$)
Tag (Y-LH$_n$)
Tag (Y-HH$_n$)
Packed Data
Packed Data
Packed Data
Packed Data
Tag (U-LL$_{n-1}$)
Tag (V-LL$_{n-1}$)
Tag (Y-HL$_{n-1}$)
Tag (Y-LH$_{n-1}$)
Packed Data
Packed Data
Packed Data
Packed Data
Tag (U-HH$_1$)
Tag (V-HL$_1$)
Tag (V-LH$_1$)
Tag (V-HH$_1$)
Packed Data

FIGURE 54

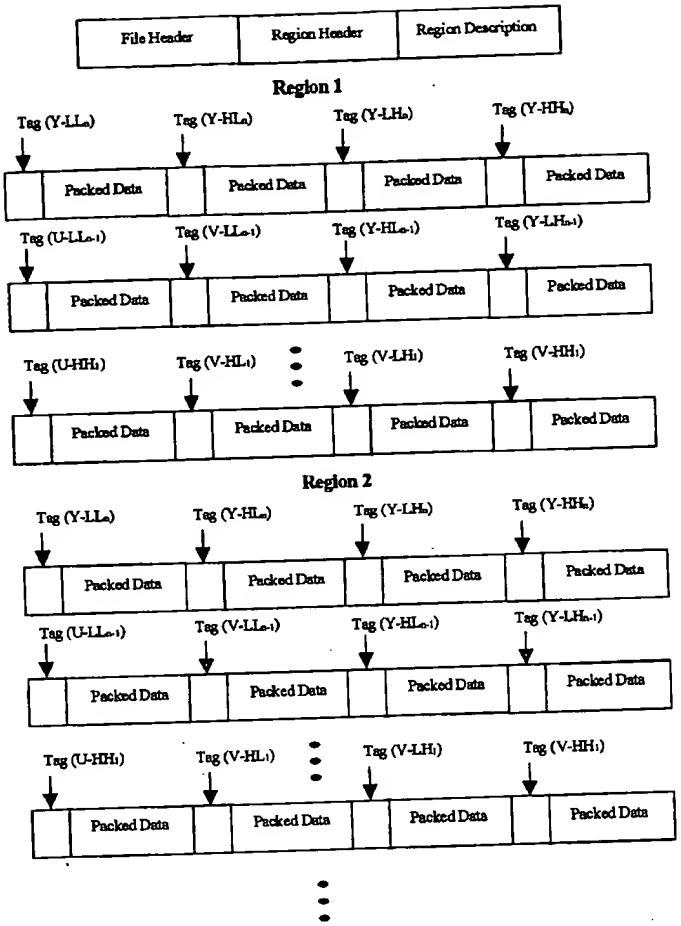

File Header
Region Header
Region Description
Region 1
Tag (Y-LL$_n$)
Tag (Y-HL$_n$)
Tag (Y-LH$_n$)
Tag (Y-HH$_n$)
Packed Data
Tag (U-LL$_{n-1}$)
Tag (V-LL$_{n-1}$)
Tag (Y-HL$_{n-1}$)
Tag (Y-LH$_{n-1}$)
Tag (U-HH$_1$)
Tag (V-HL$_1$)
Tag (V-LH$_1$)
Tag (V-HH$_1$)
Region 2

FIGURE 55

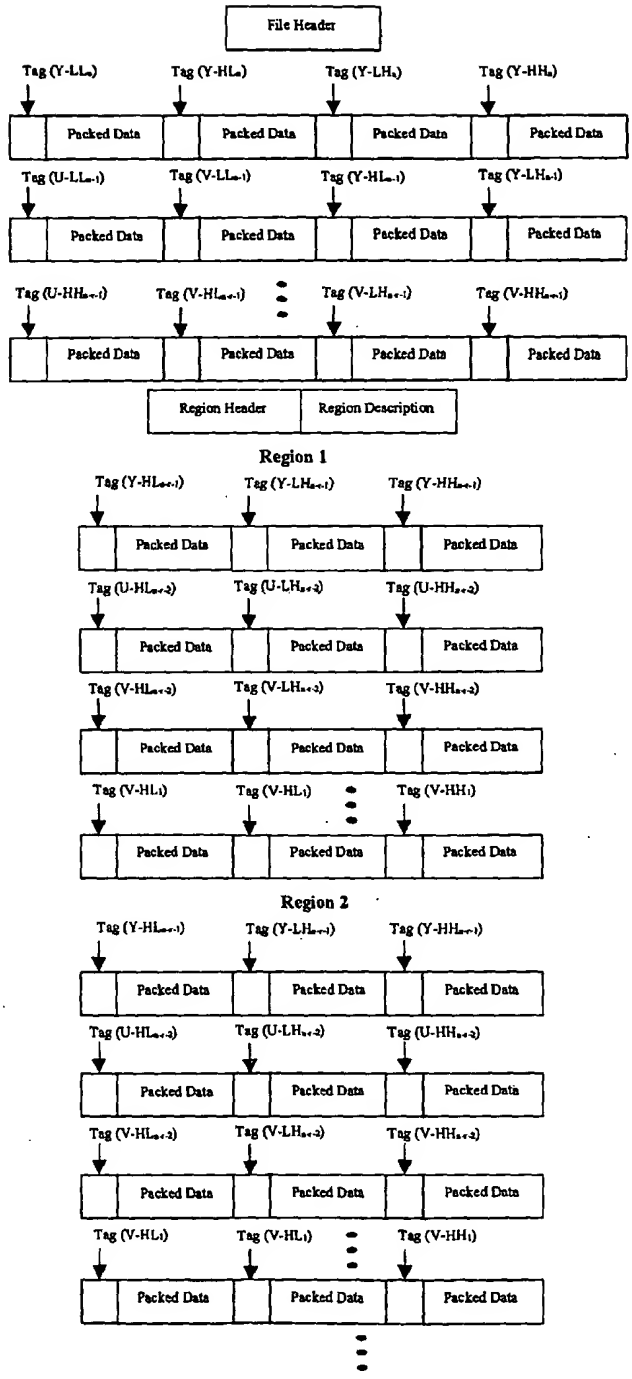

File Header
Tag (Y-LL$_n$)
Tag (Y-HL$_n$)
Tag (Y-LH$_n$)
Tag (Y-HH$_n$)
Packed Data
Tag (U-LL$_{n-1}$)
Tag (V-LL$_{n-1}$)
Tag (Y-HL$_{n-1}$)
Tag (Y-LH$_{n-1}$)
Tag (U-HH$_{n-1}$)
Tag (V-HL$_{n-1}$)
Tag (V-LH$_{n-1}$)
Tag (V-HH$_{n-1}$)
Region Header
Region Description
Region 1
Tag (Y-HL$_{n-1}$)
Tag (Y-LH$_{n-1}$)
Tag (Y-HH$_{n-1}$)
Tag (U-HL$_{n-2}$)
Tag (U-LH$_{n-2}$)
Tag (U-HH$_{n-2}$)
Tag (V-HL$_{n-2}$)
Tag (V-LH$_{n-2}$)
Tag (V-HH$_{n-2}$)
Tag (V-HL$_1$)
Tag (V-HL$_1$)
Tag (V-HH$_1$)
Region 2

FIGURE 56

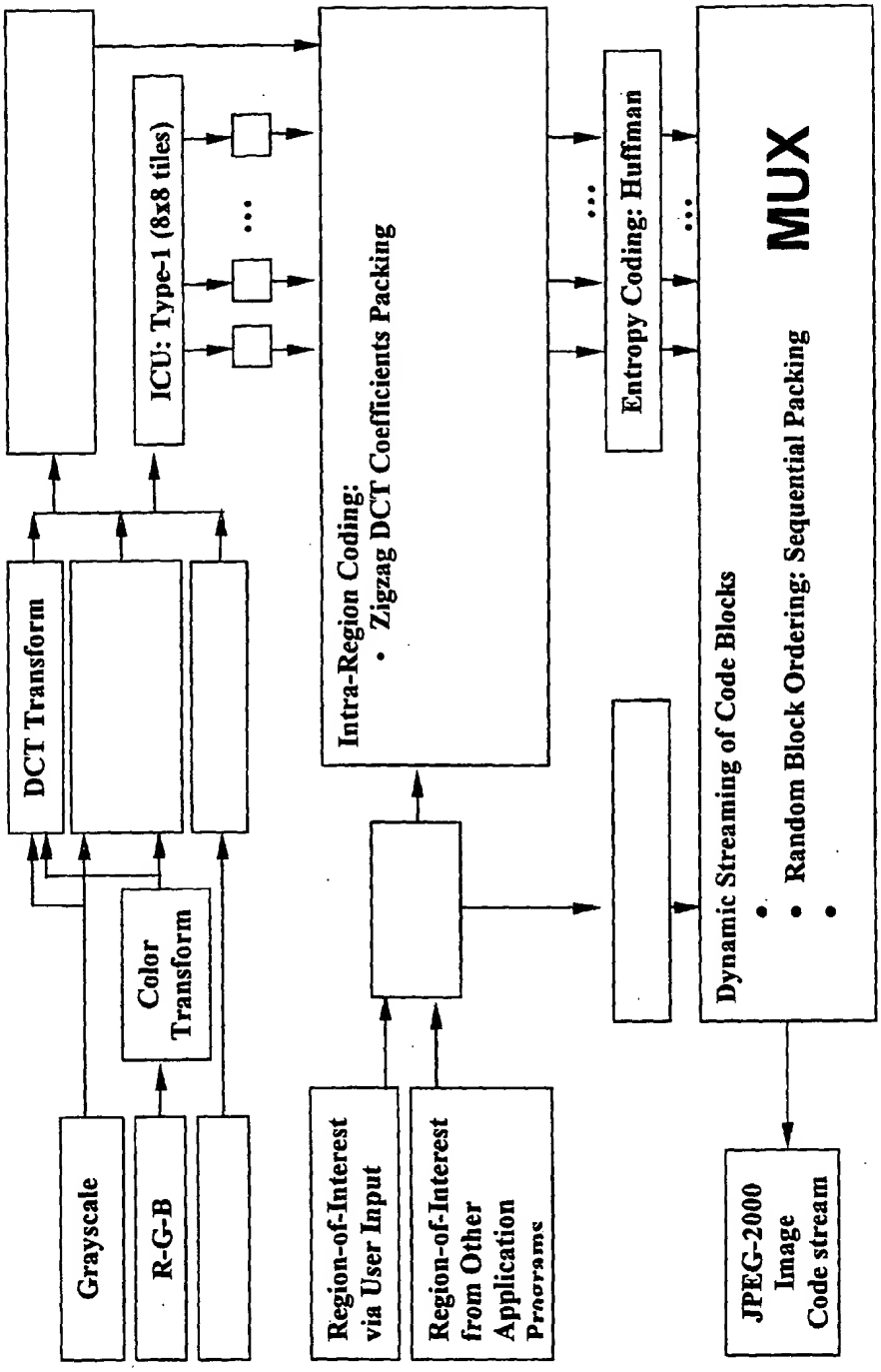

Grayscale
R-G-B
Color Transform
DCT Transform
ICU: Type-1 (8x8 tiles)
Intra-Region Coding:
• Zigzag DCT Coefficients Packing
Entropy Coding: Huffman
MUX
Dynamic Streaming of Code Blocks
• Random Block Ordering: Sequential Packing
Region-of-Interest via User Input
Region-of-Interest from Other Application
JPEG-2000 Image Code stream

FIGURE 57

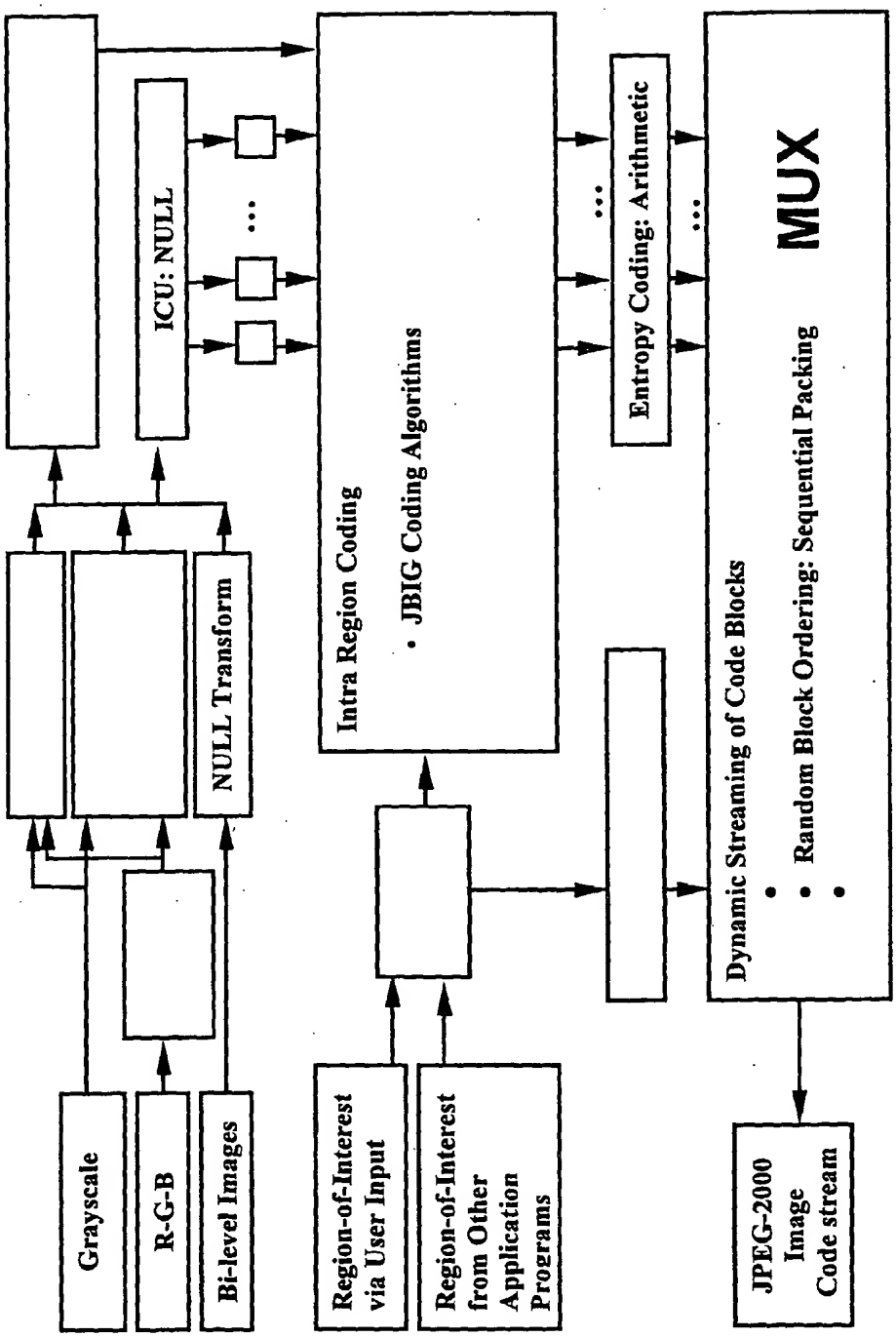

Grayscale
R-G-B
Bi-level Images
NULL Transform
ICU: NULL
Intra Region Coding
• JBIG Coding Algorithms
Entropy Coding: Arithmetic
MUX
Dynamic Streaming of Code Blocks
• Random Block Ordering: Sequential Packing
Region-of-Interest via User Input
Region-of-Interest from Other Application Programs
JPEG-2000 Image Code stream

FIGURE 58

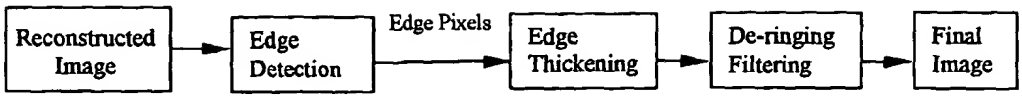


FIGURE 59

Re-constructed Image VM 3.0 (B) Post-Processing Adaptive Post-Processing

FIGURE 60

FIGURE 61

C mpression ratio	VM 3.0 (B) time (sec)	RICS Adaptive time (sec)	Compression ratio	VM 3.0 (B) time (sec)	RICS Adaptive time (sec)
3.2170	7.310	1.743	3.709	22.392	5.398
9.0140	7.260	1.702	8.889	23.023	8.151
40.210	7.325	1.482	10.000	22.442	5.288
48.763	7.170	1.462	11.428	22.232	5.809
56.492	8.262	1.402	13.333	22.462	5.878
66.550	8.703	1.382	16.000	22.482	5.629
81.143	6.769	1.362	20.001	22.522	5.489
103.716	7.171	1.175	26.666	22.382	5.568
130.168	7.170	1.222	32.000	22.422	5.338
169.019	8.310	1.132	40.002	22.352	3.896
253.337	7.130	1.052	79.987	22.282	3.465

FIGURE 62

Compression Ratio	PSNR (γ=8)	PSNR (γ=12)	PSNR (γ=16)
3.709	31.329611	31.177579	30.511348
4.000	31.300452	31.154471	30.490295
5.333	31.157031	30.994670	30.357978
8.000	30.630383	30.474574	29.862022
8.889	30.401649	30.216825	29.646734
10.000	30.067778	29.909074	29.375402
11.428	29.691347	29.546710	29.056083
13.333	29.228454	29.103298	28.645196
16.000	28.407724	28.276664	27.908937
20.001	27.508670	27.413509	27.134810
26.666	26.385419	26.307257	26.084268
32.000	25.333808	25.280108	25.111808
40.002	24.696655	24.660851	24.509536
79.987	22.179274	22.152787	22.093103
100.004	21.592595	21.568550	21.525140

FIGURE 63

Compressi n Ratio	PSNR (F=3)	PSNR (F=5)	PSNR (F=7)	PSNR (F=9)	PSNR (F=11)
1.583	35.514592	34.206867	33.687448	33.409849	33.223806
1.600	35.516204	34.201801	33.674565	33.408178	33.220934
2.000	35.314595	34.080237	33.538998	33.301232	33.090358
2.667	34.957612	33.765719	33.291270	33.011713	32.832969
4.000	34.002797	32.997735	32.564248	32.338257	32.200522
8.000	31.089735	30.554027	30.324381	30.196463	30.106473
8.889	30.572145	30.142348	29.935209	29.796335	29.725453
9.999	30.131952	29.795631	29.604549	29.472401	29.394763
11.429	29.629346	29.390456	29.261471	29.13131	29.064764
13.334	28.854873	28.701271	28.602145	28.527964	28.470308
16.000	27.870101	27.760478	27.671142	27.632609	27.579655
19.999	27.031806	26.910914	26.857123	26.835492	26.794267
26.662	25.962692	25.994100	25.999759	26.019787	25.991909
40.010	24.159134	24.178761	24.173011	24.191618	24.182049
80.020	21.654340	21.683920	21.731559	21.761676	21.774576

FIGURE 64

Compression Ratio	PSNR (F=3)	PSNR (F=5)	PSNR (F=7)	PSNR (F=9)	PSNR (F=11)
3.709	31.656960	30.740420	30.806267	30.511348	30.298514
4.000	31.634763	30.735842	30.791791	30.490295	30.278695
5.333	31.436411	30.558898	30.635121	30.357978	30.141580
8.000	30.819587	30.065789	30.126713	29.862022	29.680912
8.889	30.537579	29.839074	29.879854	29.646734	29.474362
10.000	30.170406	29.541099	29.603527	29.375402	29.205815
11.428	29.740858	29.186726	29.255123	29.056083	28.880456
13.333	29.255225	28.752598	28.839294	28.645196	28.494299
16.000	28.391715	27.982943	28.075866	27.908937	27.788081
20.001	27.479117	27.162369	27.270921	27.134810	27.012976
26.666	26.329007	26.079132	26.175590	26.084268	25.999266
32.000	25.279960	25.088255	25.181387	25.111808	25.044080
40.002	24.649334	24.486896	24.568579	24.509536	24.446939
79.987	22.195351	22.099853	22.127757	22.093103	22.066329
100.004	21.598939	21.520845	21.561808	21.525140	21.501686

FIGURE 65

Comp Ratio	MSE C4	PSNR C4	MSE C6	PSNR C6	MSE C8	PSNR C8	MSE C10	PSNR C10
1.583	7.765411	39.229159	14.264114	36.588355	20.262634	35.063845	24.678070	34.207692
1.600	7.783203	39.219220	14.271622	36.586070	20.312759	35.053114	24.757339	34.193764
2.000	8.327881	38.925459	14.998596	36.370297	21.123337	34.883178	25.556641	34.055766
2.667	9.692001	38.266669	16.493225	35.957748	22.997864	34.513929	27.498306	33.737744
4.000	14.722046	36.451122	21.984375	34.709662	28.808853	33.535544	33.097488	32.932853
8.000	44.483109	31.648852	49.900986	31.149712	55.549133	30.684031	59.073853	30.416851
8.889	52.799194	30.904531	57.667984	30.521456	62.367477	30.181222	65.356079	29.977944
9.999	60.632019	30.303783	64.887344	30.009204	68.774963	29.756500	71.202606	29.605845
11.429	69.232758	29.727687	72.769318	29.511321	75.513184	29.350576	77.597198	29.232327
13.334	82.567825	28.962695	85.462585	28.813043	87.943863	28.688748	89.701675	28.602798
16.000	105.474950	27.899311	108.281906	27.785245	109.973099	27.717939	111.452667	27.659899
19.999	131.348300	26.946559	133.166946	26.886839	134.350037	26.848426	134.844223	26.832480
26.662	166.120390	25.926574	165.26181	25.949079	164.059326	25.980794	163.365967	25.999188
40.010	249.851910	24.153977	249.164856	24.165936	248.268158	24.181593	247.954636	24.187081
80.020	439.120450	21.704967	437.621460	21.719818	435.972107	21.736217	434.750366	21.748404

FIGURE 66

Comp Ratio	MSE C12	PSNR C12	MSE C14	PSNR C14	MSE C16	PSNR C16
1.583	29.654831	33.409849	35.271851	32.656521	41.355957	31.965423
1.600	29.666245	33.408178	35.268005	32.656995	41.379425	31.962959
2.000	30.405853	33.301232	36.249649	32.537766	42.367616	31.860463
2.667	32.501923	33.011713	38.265869	32.302688	43.982712	31.697984
4.000	37.953751	32.338257	43.370041	31.758905	48.739197	31.252020
8.000	62.148987	30.196463	65.897278	29.942129	69.077271	29.737452
8.889	68.147018	29.796335	70.858078	29.626910	73.575455	29.463474
9.999	73.424377	29.472401	75.886185	29.329176	78.898651	29.160108
11.429	79.423569	29.131310	81.619110	29.012885	84.361023	28.869385
13.334	91.260742	28.527964	93.198953	28.436833	95.293335	28.340178
16.000	112.155212	27.632609	113.068161	27.597400	114.424561	27.545611
19.999	134.750748	26.835492	135.182816	26.821589	135.73201	26.803981
26.662	162.592941	26.019787	162.833038	26.013378	163.141922	26.005148
40.010	247.695740	24.191618	248.170792	24.183297	249.198486	24.165350
80.020	433.423813	21.761676	433.733047	21.758578	434.813171	21.747777

FIGURE 67

Comp Ratio	MSE C6	PSNR C6	MSE C8	PSNR C8	MSE C10	PSNR C10
3.709	40.866048	32.017177	48.42193[illegible]	31.280383	53.364817	30.858253
4.000	41.139272	31.988238	48.628245	31.261918	53.618078	30.837691
5.333	43.182419	31.777734	50.741887	31.077137	55.548584	30.684074
8.000	50.567963	31.092049	57.770162	30.513768	62.558919	30.167911
8.889	54.322367	30.781017	61.445058	30.245934	65.941528	29.939214
10.000	59.253784	30.403643	66.186651	29.923100	70.753092	29.633349
11.428	65.823085	29.947021	72.189621	29.546056	76.476232	29.295539
13.333	73.587957	29.462736	80.245789	29.086581	84.515152	28.861458
16.000	90.881770	28.546036	97.184072	28.254853	101.208043	28.078653
20.001	113.080653	27.596921	118.35673	27.398874	122.169271	27.261184
26.666	147.815740	26.433597	152.951072	26.285258	156.646398	26.181599
32.000	189.147156	25.362805	193.993169	25.252939	197.467316	25.175851
40.002	219.816732	24.710196	224.114268	24.626109	227.036153	24.569853
79.987	388.352183	22.238546	393.958450	22.176299	397.816293	22.133956
100.004	446.311579	21.634422	450.886418	21.590113	454.329178	21.557097

FIGURE 68

Comp Ratio	PSNR R1	PSNR R2	PSNR R3	PSNR R4	PSNR R5
1.583	36.574570	34.642943	33.409849	32.697519	32.241311
1.600	36.562052	34.637526	33.408178	32.690100	32.238019
2.000	36.362537	34.486701	33.301232	32.599597	32.146102
2.667	35.932465	34.134055	33.011713	32.347816	31.926978
4.000	34.722586	33.301598	32.338257	31.778517	31.416868
8.000	31.264379	30.640440	30.196463	29.892131	29.673122
8.889	30.660431	30.183697	29.796335	29.547117	29.365451
9.999	30.201141	29.800439	29.472401	29.244209	29.090109
11.429	29.706536	29.398255	29.131310	28.942109	28.805907
13.334	28.946950	28.733637	28.527964	28.378407	28.263955
16.000	27.924645	27.784119	27.632609	27.510373	27.424183
19.999	27.018210	26.938891	26.835492	26.749663	26.687918
26.662	26.025142	26.045564	26.019787	25.971153	25.921551
40.010	24.209514	24.214338	24.191618	24.152663	24.116273
80.020	21.70436	21.747276	21.761676	21.762267	21.751451

FIGURE 69

Parameter	Number of Bits	Value Range
Mask Threshold	7	0-127
Mask Width	4	5-20
Estimation Threshold	4	5-20
Filter Length	3	3-10
Constraints	4	3-18
Iteration	2	1-4

FIGURE 70